SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 151, NUMBER 9

Charles D. and Mary Vaux Walcott Research Fund

FOUR NEW EOCENE ECHINOIDS FROM BARBADOS

(With One Plate)

By
PORTER M. KIER

Museum of Natural History
Smithsonian Institution

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
AUGUST 30, 1966

Smithsonian Publication 4673

PORT CITY PRESS, INC.
BALTIMORE, MD., U. S. A.

Charles D. and Mary Vaux Walcott Research Fund

FOUR NEW EOCENE ECHINOIDS FROM BARBADOS

By

PORTER M. KIER

Museum of Natural History, Smithsonian Institution

(With One Plate)

Two new species of *Cassidulus*—one of *Echinocyamus* and one of *Fibularia*—are described from the middle Eocene Upper Scotland Formation in Barbados. The specimens were collected by Alfred Senn and A. J. Mestier in 1937 and sent to me for study by H. G. Kugler.

The new species of *Fibularia* is particularly interesting because of the large number of specimens available, making possible a study of its variation and ontogeny. Although it occurs throughout the Upper Chalky Mount Member, no evolutionary trends were found within the species.

It was necessary to reexamine the American species in order to compare the Barbadian species of *Echinocyamus* and *Fibularia* with the American, most of which have been inadequately described and illustrated. All available specimens have been measured and the data are presented on scatter diagrams. Drawings are included of their tests, showing for the first time the location of their petal pores, the most diagnostic feature in these species.

PREVIOUS WORK

Only three species of echinoids have been described from Barbados, *Cystechinus crassus* Gregory (1889, p. 641), *Eupatagus abruptus* (Gregory, 1892, p. 163), and *Echinolampas anguillae* Cotteau (Guppy, 1911, p. 692). All these species are from the Oceanic Formation which is considered to be Middle Eocene to Oligocene. The species described below are the first that have ever been recorded from the Upper Scotland Formation.

The Barbadian Upper Scotland mollusca have been described by Trechmann (1925), the crustaceans by Withers (1926), the larger Foraminifera by Vaughan (1945), the corals by Wells (1945), and the Nummulites by Cizancourt (1948).

AFFINITIES OF ECHINOIDS

It is rather surprising, considering the large number of echinoids known from Eocene rocks in the Caribbean and southeastern United States, that all the four species from the Upper Scotland Formation are new and quite distinct. Vaughan (1945, p. 20) reported a similar situation among the Foraminifera with 9 out of 12 species new, and in the corals Wells (1945, pp. 1-2) found 16 new species of corals with only 2 previously known from other localities.

ECOLOGY

Evidently the echinoids lived in the sediment in which they were fossilized. The Upper Scotland Formation is a sand or a conglomerate in most localities where the echinoids were collected. Two of the echinoid species are fibularids and according to Mortensen (1948, p. 162) members of this family commonly live in sands and gravels. The other two species are cassiduloids which also are reported (Kier, 1962, p. 21) to live in sand.

The echinoids are of no use in determining the depth of the sea during deposition of the Upper Scotland Formation. Species of *Echinocyamus* are found in water from 20 to 1,886 meters deep, and *Fibularia* from littoral to 400 meters. The bathymetrical distribution is not known with certainty for any living species of *Cassidulus*. Vaughan (1945, p. 21) stated that the Foraminifera and corals indicated relatively shallow water not greater than 183 meters and probably as shallow as 73 meters.

STRATIGRAPHIC DATA

Most of the echinoids were collected from the Chalky Mount Member of the Upper Scotland Formation. According to Vaughan (1945), "the foraminifera fauna of the Upper Scotland Formation is obviously middle Eocene, and it may be considered the type middle Eocene larger foraminiferal fauna of America." The lower half (50-100 meters thick) of the Chalky Mount Member (Senn 1940, p. 1554) consists of massive to coarse-bedded gritty sands, alternating with a few well-bedded finer-grained sands. The upper half consists

of an alternation of friable, coarse, gritty sands, and medium-grained sands, with a thickness of 20-40 meters.

COLLECTION DATA

The echinoids were collected at the localities listed below. The position of these localities on a map can be found in Vaughan (1945, pl. 1). Detailed lithologic data for each site are also available in Vaughan (1945, pp. 6-18). The holotypes and figured paratypes are in the Naturhistorisches Museum, Basel, Switzerland, and the remainder of the collection is in the U.S. National Museum.

Upper Scotland Formation

Upper Chalky Mount Member

S102a,b Base of member. Northern slope of Chalky Mount (Parish of St. Andrew).

S168 Northern slope of Chalky Mount, near locality S102

S1114 Northern slope of Chalky Mount, NE of summit (Parish of St. Andrew).

Middle Chalky Mount Member

S58 Left bank of Mount Hillaby River, 46-54 m. E of Murphys-Friendship road (Parish of St. Andrew).

S80 Base of member. Slope between Spa Peak and Canegarden River on western side of cross-fault scarp (Parish of St. Joseph).

S160 Small hill on Lowes Ridge, 100 m. NW of ruin of Lowes windmill, Trechmann's locality "Sunbeam" (Parish of St. Andrew).

S359 Western part of Chalky Mount massif, NE side of flat-topped ridge 80-90 m. south of S375 and 165-180 m. SSW of S360 (Parish of St. Andrew).

S360 Upper part of member. Prominent ridge in western part of Chalky Mount massif, approx. 550 m. WSW of highest summit of Chalky Mount (Parish of St. Andrew).

S361 Ridge directly north of highest peak of Chalky Mount (Parish of St. Andrew).

S375 Upper part of member. Western part of Chalky Mount massif, in small ravine, approx. 100 m. SW of S360 (Parish of St. Andrew).

S378 Upper part of member. East side of ridge between Murphys River Valley and Goggins River Valley.

S1107 North of Chalky Mount (Parish of St. Andrew).

Lower Chalk Mount Member

S152 Top of member. Footpath on northeastern side of Spa Peak (Parish of St. Joseph).

S164, 165 Eastern end of Chalky Mount near Benab (Parish of St. Andrew).

S379 Upper part of member. Chalky Mount West (Parish of St. Andrew).

Chalky Mount Member

S1108 Goggins Hill

Murphys Member

S110 Senn test pit 88, near end of cart track, 330 m. SE of Turner's Hall Estate house (Parish of St. Andrew).

SYSTEMATIC DESCRIPTIONS

FIBULARIA BARBADOSENSIS Kier, new species

(Pl. figs. 1-3; text figs. 1-4, 5A, 6A, 8, 9)

Diagnosis.—Species characterized by short petals.

Material.—One hundred and fifty specimens; most well preserved, but pore-pairs not easily visible in most specimens until adapical surface slightly polished with dental drill, then etched slightly with hydrochloric acid.

Shape.—Elongate, average width 80 percent of length, varying from 65 percent in the narrowest (text figs. 1, 5A) to 93 percent in widest; greatest width anterior to center; in some specimens marginal outline slightly pentagonal, in others oval with smooth marginal outline; height averages 63 percent of length, varying from 50 to 75 percent (text fig. 1).

Apical system.—Plate arrangement not visible, four genital pores, anterior pores closer together than posterior; system anterior; number of hydropores not certain.

Petals.—Petal III slightly longer than other petals, usually with one or two more pore-pairs in each poriferous zone than in poriferous zone of other petals; in holotype (text fig. 4C), 8.9 mm long, 11-12 pore-pairs in poriferous zone of petal III, 9-10 in other petals; petals widely open with greatest width at extremity of petal; petals relatively short, petals III, II, and IV extending two-thirds distance from apical system to margin, petals V and I one-half distance; pore-pairs near extremities of petals same distance apart from adjacent pair as pore-pairs near apical system; pores of pair strongly oblique to each other, outer pore more distant from apical system than inner.

Accessory pores.—Small accessory pores (text fig. 2B) along all sutures except perradial, of ambulacral plates beyond petals.

Peristome.—Central to slightly posterior to center; circular to slightly pentagonal; diameter in adults averaging 10 percent of length

of test, varying from 9.3 to 11 percent; one sphaeridium pit behind each pair of buccal pores (pl. fig. 3).

Periproct.—Circular, in adult specimens located nearer to peristome than to posterior margin; distance from peristome very variable averaging 12 percent of length of test, varying in adults from 8 to 17 percent.

Growth.—Because of the presence of very small specimens, the smallest 1.8 mm. long, a growth study was made. The length to width, and length to height ratio (text fig. 1) remain unchanged through the growth of the echinoid. Likewise, the rate of the introduction of new pores (text fig. 6) is unaltered. However, there is a marked change in the relative size of the peristome. In the smallest specimen (text fig. 4A) it is very large relative to the size of the test, having a diameter 23 percent of the length of the test, but in the largest (text fig. 4C) it is only 9 percent of the length. Apparently, as evident from the graph in text fig. 3, the peristome when first formed was initially large. The relative position of the periproct changes with growth. In the smallest specimen (text fig. 4A) it is distant from the peristome with the distance from the two equaling 20 percent of the length of the test, whereas in the largest specimen (text fig. 4C) it is much nearer to the peristome with the distance being only 11 percent of the length. No genital pores are visible in the smallest specimen, 1.8 mm long (text fig. 4A), but they are present on a specimen (text fig. 4B) 3.1 mm long.

Comparison with other species.—Six other species of *Fibularia* are known from the Caribbean and southeastern United States: *Fibularia texana* (Twitchell), *Fibularia alabamensis* Cooke from the Eocene of southeastern United States, *Fibularia minuta* Palmer from the Eocene of Cuba, *Fibularia jacksoni* Hawkins from the Eocene of Jamaica, and *Fibularia farallonensis* Cooke from the Eocene of Trinidad. With the exception of *F. jacksoni,* none of these species have ever been adequately described or illustrated. Because of the great variation in the shape of the test in this genus, it is necessary to measure many specimens before the specific characters can be delineated. Furthermore, because of the small size of the test, photographs do not usually show the position of the petal pores, the most diagnostic feature in the fibularids. Fortunately, many specimens of the American species are available in the U.S. National Museum. These have been measured and drawings of their tests and scatter diagrams of some of their dimensions are included herein. Unfortunately, Palmer's

species has never been figured and his description is too brief to be of use. *F. barbadosensis* cannot be compared to it at this time.

Of all these species, *F. barbadosensis* resembles most *F. alabamensis.* It is very similar in shape, having the same length to width ratio as is evident on a scatter diagram (text fig. 1A) in which there is no separation of the points of the two species, but it is slightly lower than *F. alabamensis,* as evident on text fig. 1B. Its peristome is slightly smaller than the Alabama species (text fig. 3), and there are usually one or two less pore-pairs in the poriferous zones of the petals (text fig. 6A). The distance of the periproct from the peristome is approximately the same for each species (text fig. 2A). The most important difference between the two species is that in *F. barbadosensis* the petals do not extend as near to the margin. This difference is clearly shown in text figure 5.

F. barbadosensis is similar to *F. texana* (Twitchell) (text fig. 7A) but differs from it in having shorter petals and more widely separated genital pores. It is easily distinguished from *F. vaughani* (Twitchell) by its smaller peristome (text fig. 7B) and shorter petals (text fig. 7B). Furthermore, in *F. barbadosensis* the distal pore-pairs of each petal are close together, whereas in *F. vaughani* the last one or two pore-pairs are more widely separated from each other than the pore-pairs nearer the apical system.

F. barbadosensis differs from *F. jacksoni* in having a slightly narrower test (text fig. 1A), more pore-pairs in petal III (text fig. 6A), shorter petals with narrower interporiferous zones, and a less pentagonal marginal outline. As can be seen from text figures 1B, 2A, it cannot be distinguished from it by the distance of the periproct from the peristome or by the height of its test.

F. barbadosensis is easily distinguished from *F. farallonensis* (text fig. 6B) by its narrower test, shorter, narrower petals, and more anteriorly situated periproct.

Evolution.—Because specimens of this species occur throughout the Chalky Mount Member (90-200 meters thick) of the Scotland Formation, a search was made for evolutionary trends such as those found by Kier (1957, p. 863; 1964, p. 1123) in other fibularids. The length, width, height, number of pore-pairs in petal III, and distance of the periproct from the peristome is recorded on graphs (text figs. 8, 9), but no distinction is apparent between specimens from the various parts of the Chalky Mount Member. The sands and conglomerates of the Member were probably deposited so rapidly that there was insufficient time for any evolutionary trends to be developed.

Occurrence.—Upper Scotland Formation, Upper Chalky Mount Member: S102a, b, S1114; Middle Chalky Mount Member: S58, S80, S160, S359, S360, S361, S375, S378, S1107; Lower Chalky Mount Member: S152, S164, S165, S379; Chalky Mount Member: S1108; Murphys Member S110.

Types.—Holotype, Basel M6603; figured paratypes M6600, M6601, M6602, M6603.

ECHINOCYAMUS CARIBBEANENSIS Kier, new species

(Pl. figs. 4, 5; text figs. 10-12A-D)

Diagnosis.—Species characterized by long petal III, wide, thick test, and position of periproct near posterior margin.

Material.—Ten specimens, largest 5.9 mm long.

Shape.—Elongate, average width 81 percent of length (text fig. 10B); greatest width slightly posterior to center; height (text fig. 10A) averages 53 percent of length, test slightly protruding at periproct, sunken around peristome.

Apical system.—Plate arrangement not visible, four genital pores, anterior pores closer together than posterior; system central to slightly anterior.

Petals.—Petal III longer than other petals, with approximately three or four more pore-pairs; in holotype, 11 pore-pairs in petal III, 7 in other petals; petals widely open (text fig. 12A), with greatest width in paired petals two-thirds distance from apical system to extremity of petals; in petal III greatest width at extremity; pores of pair oblique from each other, outer pore more distant from apical system than inner.

Accessory pores.—Small accessory pores along suture between ambulacra and interambulacra beyond petals.

Peristome.—Circular, sunken, central or slightly posterior, diameter of opening varying from 17 to 20 percent of length of test; one sphaeridium pit behind each pair of buccal pores.

Periproct.—Circular, located at posterior margin in most specimens, but in largest, 5.9 mm long, periproct more anterior (text fig. 12D), tilting so that opening faces slightly posteriorly.

Comparison with other species.—*E. caribbeanensis* is easily distinguished from *E. macneili* from the late Eocene of Alabama by its wider and thicker test (text fig. 10), more pore-pairs in petal V relative to length (text fig. 11A), and periproct nearer the posterior margin (text fig. 13A). In the holotype and only known specimen of *E. macneili,* the genital pores are much larger than those in *E. carib-*

beanensis, but as suggested by Cooke (1959, p. 33) this specimen may have had larger pores because it may have been a female.

E. caribbeanensis differs from *E. huxleyanus* Meyer from the late middle Eocene Gosport sand in having a wider and higher test (text figs. 10A, B), longer petal III (text fig. 12E), more pore-pairs in petal V relative to length (text fig. 11A), small genital pores (text fig. 12E), and the periproct nearer the posterior margin (text fig. 12E). *E. caribbeanensis* differs from *E. parvus* Emmons from the late middle Eocene Castle Hayne Limestone of North Carolina in having a wider, thicker test (text figs. 10A, B), longer petal III (text figs. 11B, 13B), more pore-pairs in petal V relative to length (text fig. 11A), periproct nearer the posterior margin, and its genital pores closer together (text fig. 13B). It is easily distinguished from *E. meridionalis* Meyer from the Eocene of Alabama and Mississippi by its narrower and higher test (text figs. 10A, B). It is unfortunate that none of the specimens of *E. meridionalis* in the U.S. National Museum shows the petaloid region. Finally, it differs from *E. chipolanus* Cooke from the early Miocene of Florida in having a higher test, but because the holotype and only known specimen of this Florida species has been broken, it cannot be further compared.

Echinocyamus avilensis Lambert from the upper Eocene of Cuba has never been adequately figured, but from Lambert's (1931, p. 298) dimensions of the type it is much larger (16 mm long) and much wider, with the width (15 mm) almost equal to the length.

Occurrence.—Upper Scotland Formation, Upper Chalky Mount Member: S168; Middle Chalky Mount Member: S80, S360, S375, S1107; Lower Chalky Mount Member: S164, S165; Murphys Member: S110.

Types.—Holotype, Basel M6605, figured paratype, M6606.

CASSIDULUS SENNI Kier, new species

(Pl. figs. 6-8; text figs. 14-15)

Diagnosis.—Species characterized by small, broad test, long, broad petals, and slightly developed bourrelets.

Material.—Twenty-four specimens with surfaces poorly preserved due to secondary growth of calcite and partial silicification; details of petals and phyllodes only visible after polishing with dental wheel and etching slightly with hydrochloric acid.

Shape.—Test small, average test 8 mm long, smallest 6.8, largest

12.6 mm; elongate, width averaging 86 percent of length, very little variation in length-width ratio (text fig. 14A); greatest width posterior to center; test low, average height 40 percent of length (text fig. 15D); greatest height anterior (text fig. 15C) at apical system; deep groove leading from periproct to posterior margin; peristome sunken.

Apical system.—Anterior, four genital pores, anterior pair closer together than posterior, madreporic pores extending back between posterior genital pores; probably monobasal, but specimens too poorly preserved to be certain.

Petals.—Broad, anterior petals (text fig. 15A) extending almost to margin, posterior extending two-thirds distance from apical system to margin; petals closing slightly distally, with interporiferous zones equal in width or slightly wider than poriferous zones; posterior petals slightly longer than others with three to five more pore-pairs than in petal III, two to four more than in petals II or IV; in small specimens, 6.9 mm long, 16 pore-pairs in petal II, 16 in IV, 19 in V; in largest specimen, 12.6 mm long, 21 pore-pairs in III, 22 in IV, 26 in V; as apparent from text fig. 14B, rate of production of new pores decreases with growth.

Periproct.—Supramarginal, located slightly more than one-half distance from apical system to posterior margin; deep groove extending from opening to margin.

Peristome.—Slightly anterior of center, wider than high, pentagonal, sunken.

Floscelle.—Bourrelets slightly developed; phyllodes (text fig. 15B) wide, single pores in each plate, with slight crowding of pores, one or two pores occluded in each half-ambulacrum.

Tuberculation.—Owing to poor preservation, details of tuberculation not known.

Comparison with other species.—None of the species of *Cassidulus* known from the Caribbean or America resembles this species. Its broad and long petals, broad test, and slightly developed bourrelets readily distinguish it from all other species of *Cassidulus.*

Occurrence.—Upper Scotland Formation, Upper Chalky Mount Member: S102a, b; Middle Chalky Mount Member: S80, S360, S361, S1107; Lower Chalky Mount Member: S152; Murphys Member: S110.

Types.—Holotype, Basel M6607, figured paratypes M6608, M6609.

CASSIDULUS MESTIERI Kier, new species

(Pl. figs. 9-11; text fig. 16)

Diagnosis.—Species characterized by high test, narrow petals.

Material.—One specimen, well preserved except for erosion at apical area.

Shape.—Holotype 13.4 mm long, 12.0 mm wide, 8.6 mm high, greatest width posterior to center; test high with steep sides, greatest height slightly posterior to apical system; posterior truncated obliquely so that periproct slightly visible from above; margin rounded; adoral surface depressed around peristome.

Apical system.—Missing.

Petals.—Petals narrow (text fig. 16A), slightly widened, open distally; anterior petal shortest, extending only one-half distance from apical system to margin; posterior petals longest, almost twice as long as anterior petal.

Periproct.—Supramarginal, located high on posterior truncation; with slight groove extending from opening to posterior margin; slightly wider than high.

Peristome.—Anterior, large, pentagonal, wider than high, sunken.

Floscelle.—Bourrelets well developed, giving pentagonal outline to opening; phyllodes moderately broad (text fig. 16B), five or six pores in each half ambulacrum with one occluded pore; buccal pores.

Tuberculation.—Most of tubercles eroded.

Comparison with other species.—This species is easily distinguished from *Cassidulus senni* Kier, new species also from the Upper Scotland Formation, by its much higher test, shorter, narrower petals, more posterior periproct, and larger peristome. Of all the species of *Cassidulus* known from the Americas it resembles most *Cassidulus peruvianus* (Brighton) from the Eocene of Peru. Its narrower, shorter petals, less sloping adapical posterior surface, and higher periproct distinguish it from this Peruvian species.

Occurrences.—Upper Scotland Formation, Lower Chalky Mount Member: S164.

Type.—Holotype Basel M6610.

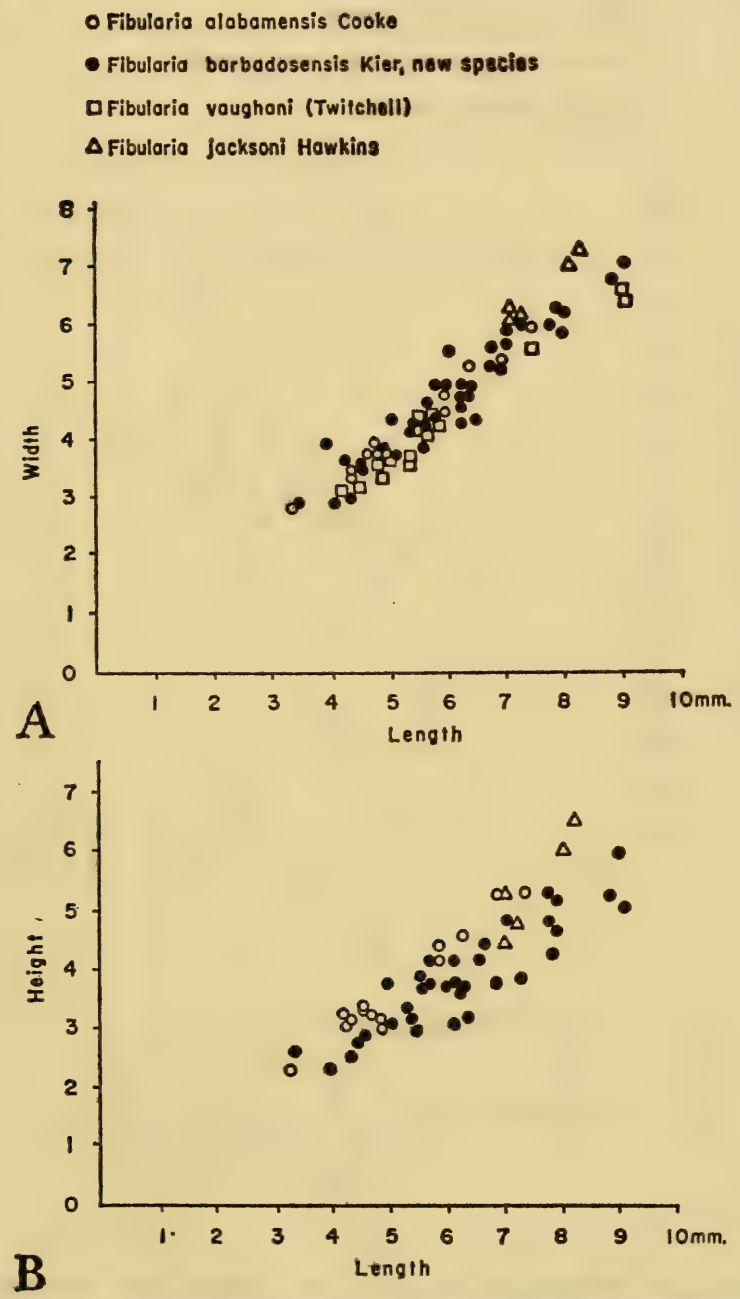


Fig. 1.—**A**, Width relative to length in *Fibularia barbadosensis, F. alabamensis, F. vaughani,* and *F. jacksoni.* **B**, Height relative to length in *F. barbadosensis, F. alabamensis,* and *F. jacksoni.*

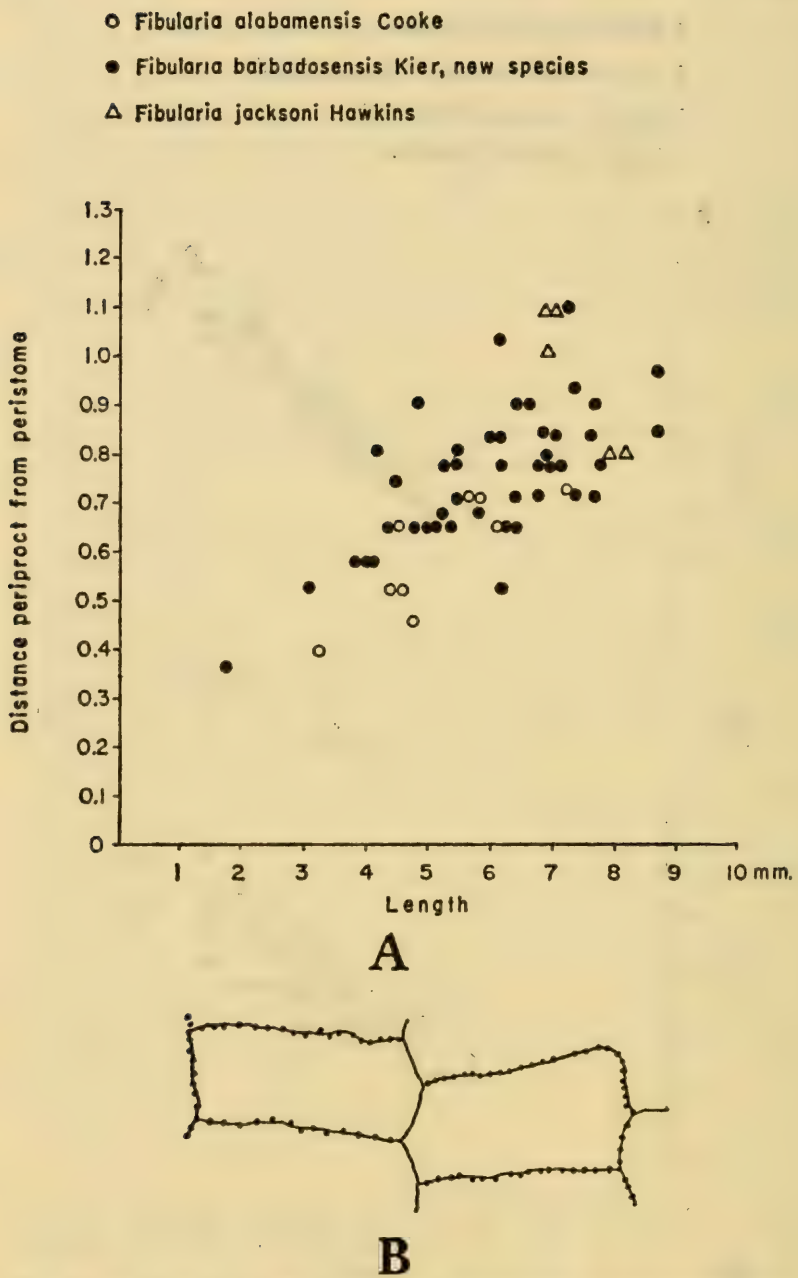


Fig. 2.—**A**, Distance of the periproct from the peristome relative to the length of the test in *Fibularia barbadosensis, F. alabamensis,* and *F. jacksoni.* **B**, *Fibularia barbadosensis* Kier, new species: Accessory pores along sutures of ambulacral plates near ambitus; Basel M 6600, loc. S80, × 35.

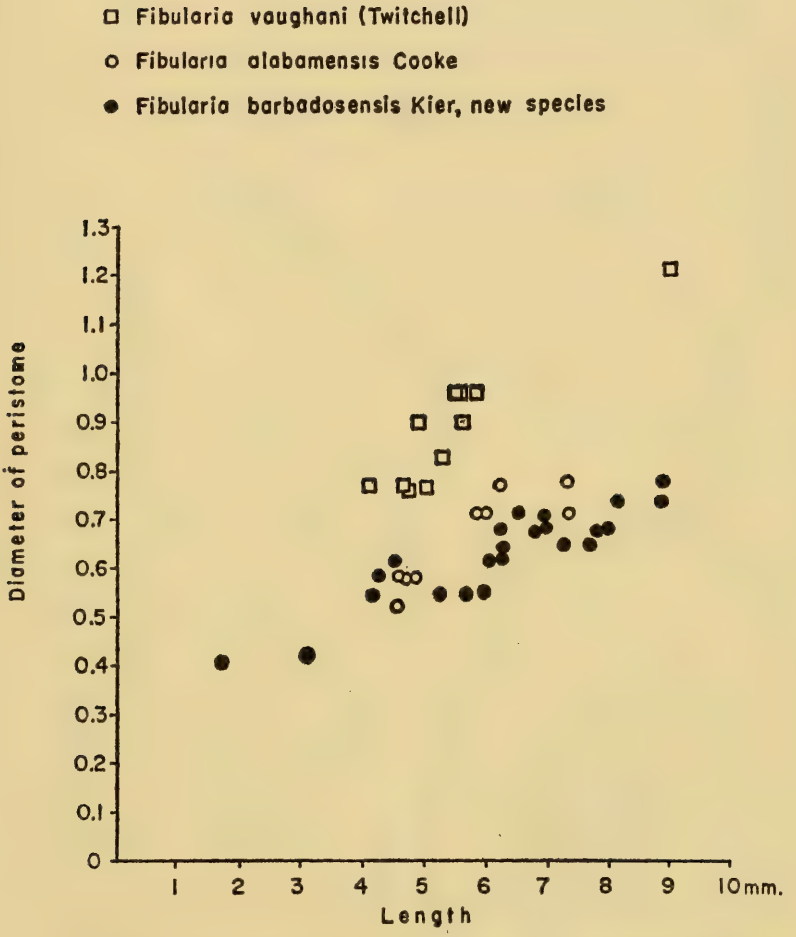


Fig. 3.—Diameter of peristome relative to length of test in *Fibularia barbadosensis, F. vaughani* and *F. alabamensis.*

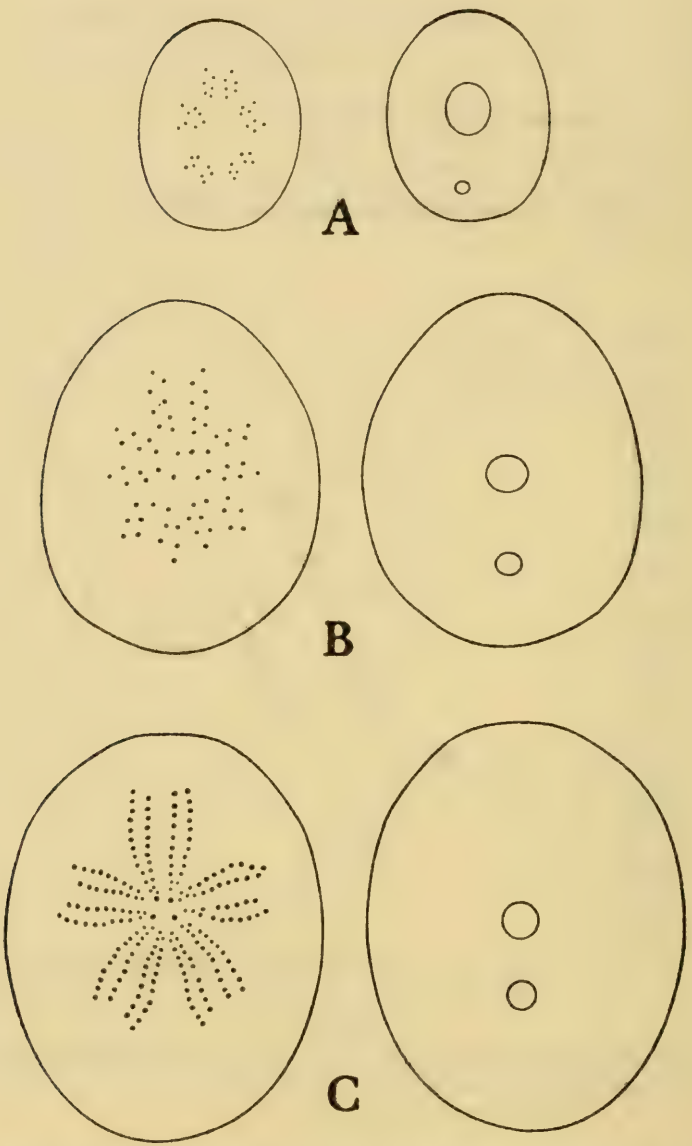


Fig. 4.—*Fibularia barbadosensis* Kier, new species: Growth series. **A,** Smallest specimen in collection, 1.8 mm long, Basel M6601, loc. S375, × 15; **B,** Specimen 3.1 mm long, Basel M6602, loc. S375, × 15; **C,** Holotype, 9.1 mm long, Basel M6603, loc. S1107, × 6.

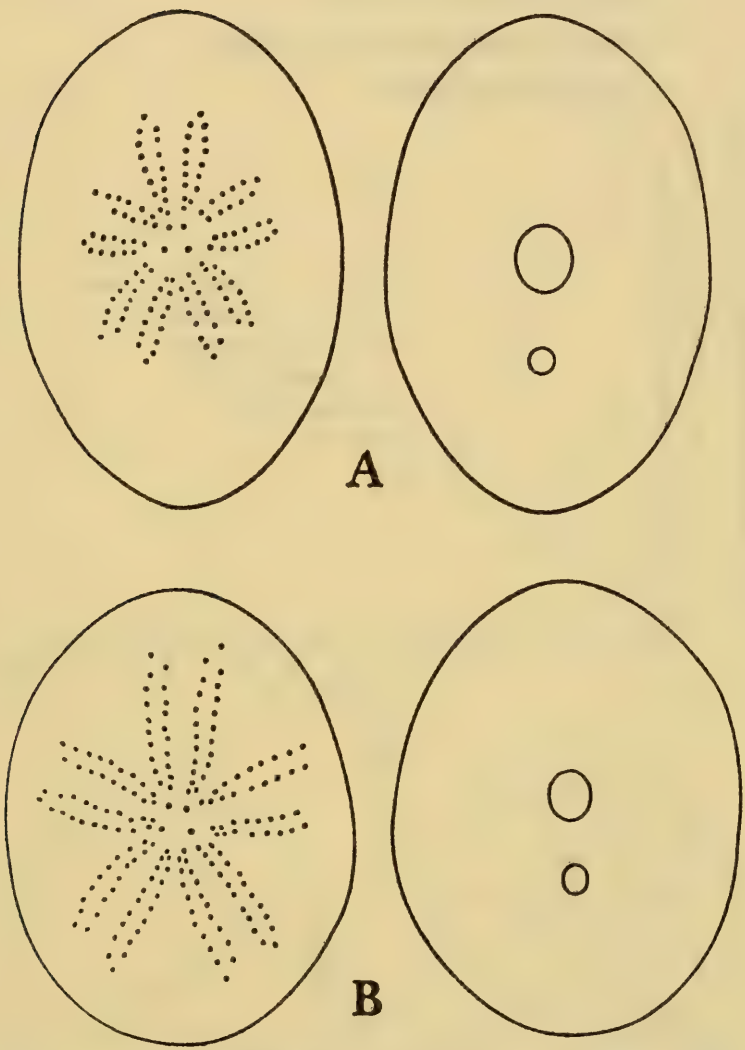


Fig. 5.—**A**, *Fibularia barbadosensis* Kier, new species: Narrow specimen, Basel M6604, loc. S1107, × 10. **B**, *Fibularia alabamensis* Cooke: Holotype, USNM 372887, upper Eocene, probably Moody Branch Formation, at USGS 10014, stream on line between sec. 20 and 29, T. 4 M., R. 15 E., 6 miles west of Andalusia, Covington Co., Alabama, × 8.

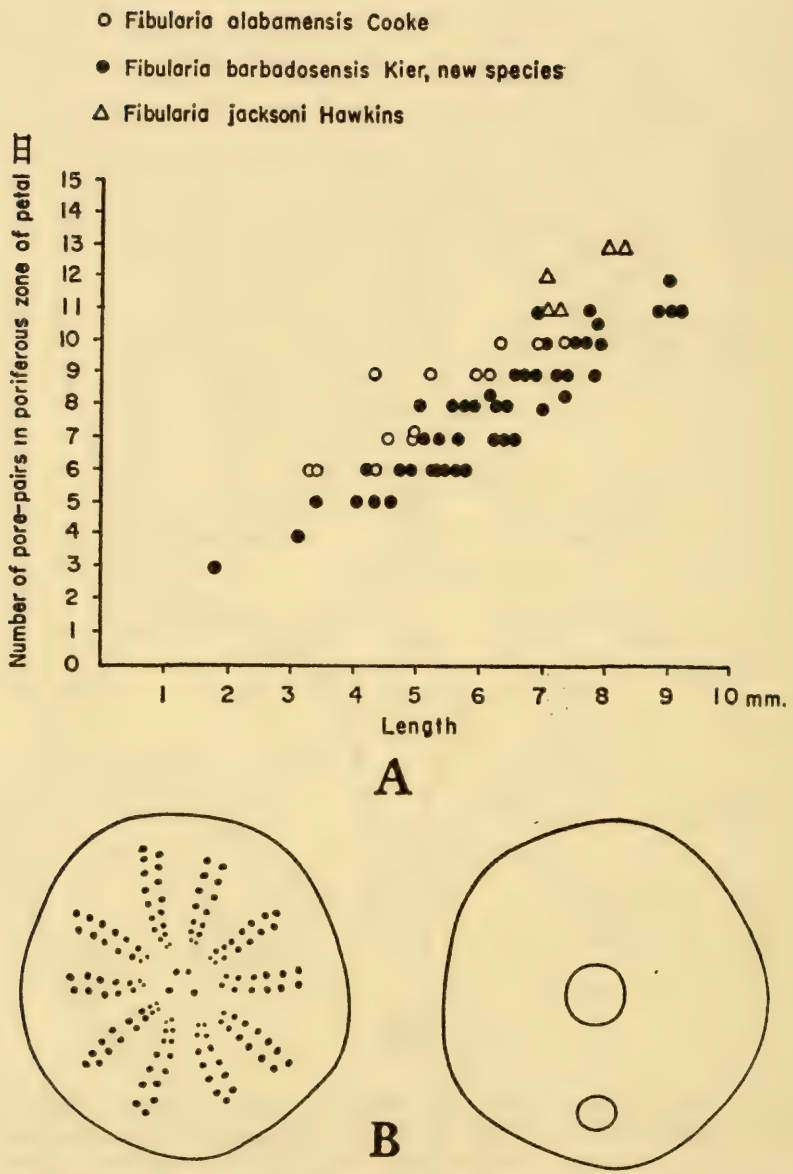


Fig. 6.—A, Relation of the number of pore-pairs in a poriferous zone of petal III to the length of the test in *Fibularia barbadosensis, F. alabamensis,* and *F. jacksoni.* B, *Fibularia farallonensis* Cooke: Holotype, USNM 638629a, middle Eocene, Navet Formation, Farallon Rock, near San Fernando, Trinidad, × 10.

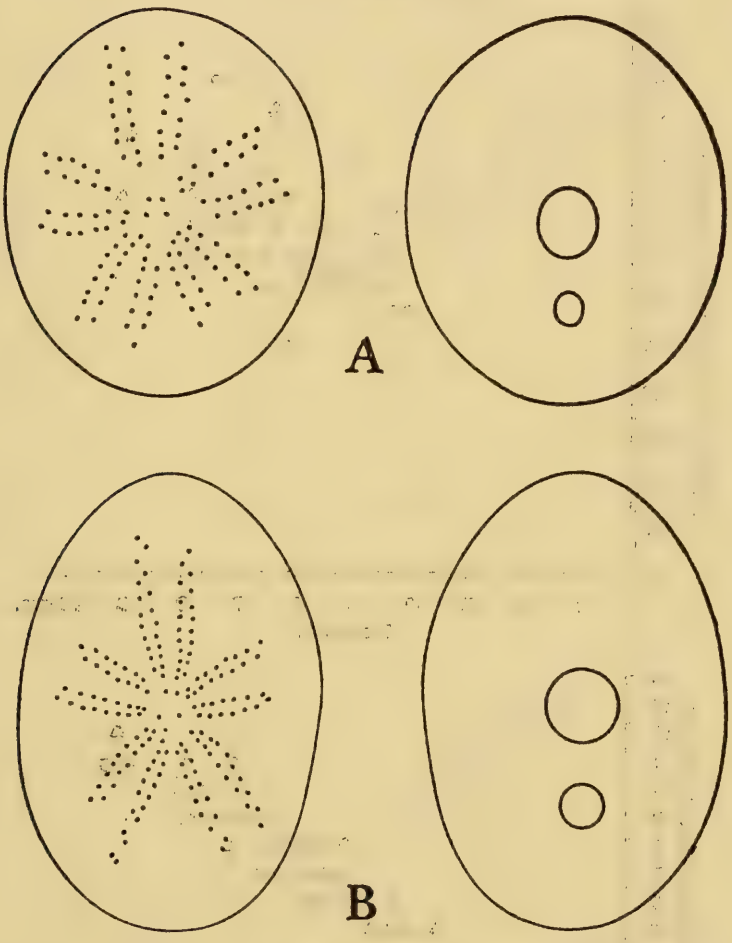


Fig. 7.—**A**, *Fibularia texana* (Twitchell): Holotype, USNM 559480, Lee County, Texas, × 10. **B**, *Fibularia vaughani* (Twitchell): Holotype, USNM 166486, late Eocene, Ocala Limestone, Flint River at Little Horseshoe Bend, 4 miles below Bainbridge, Georgia, × 8.

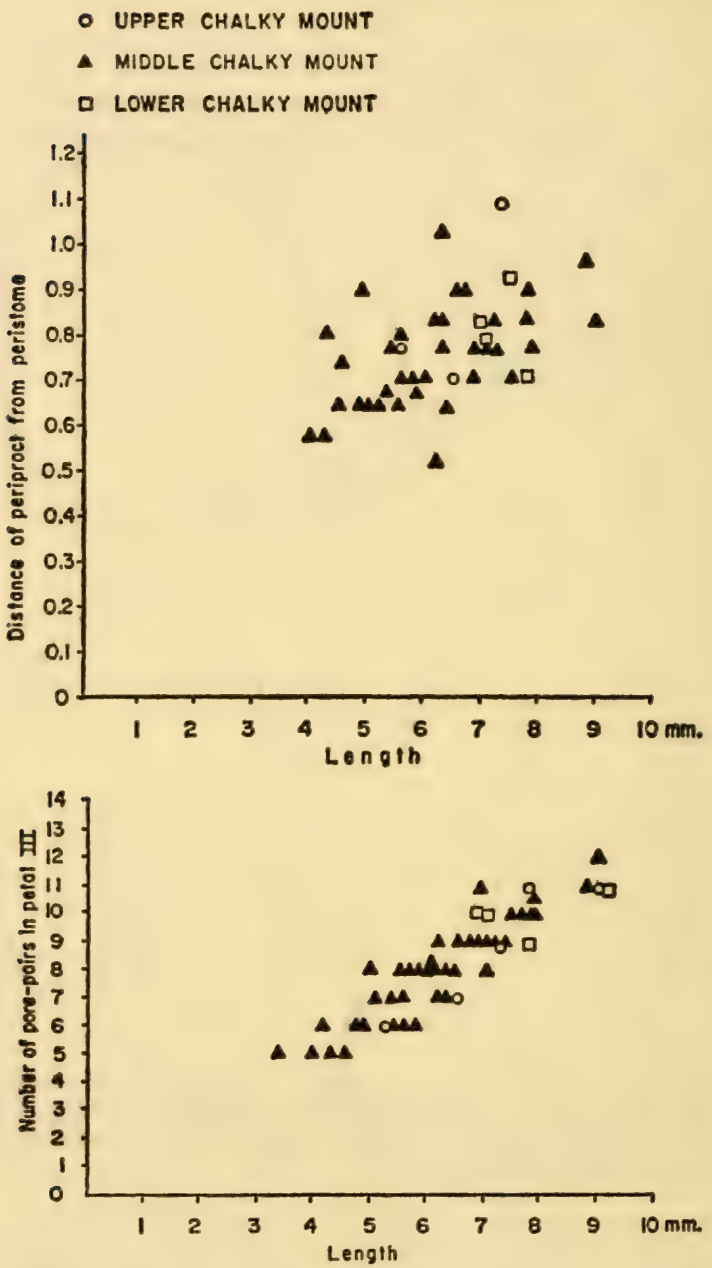


Fig. 8.—*Fibularia barbadosensis* Kier, new species: Relation of the distance of the periproct from the peristome, and the number of pore-pairs in petal III to the length in specimens from the Lower, Middle, and Upper Chalky Mount Members of the New Scotland Formation.

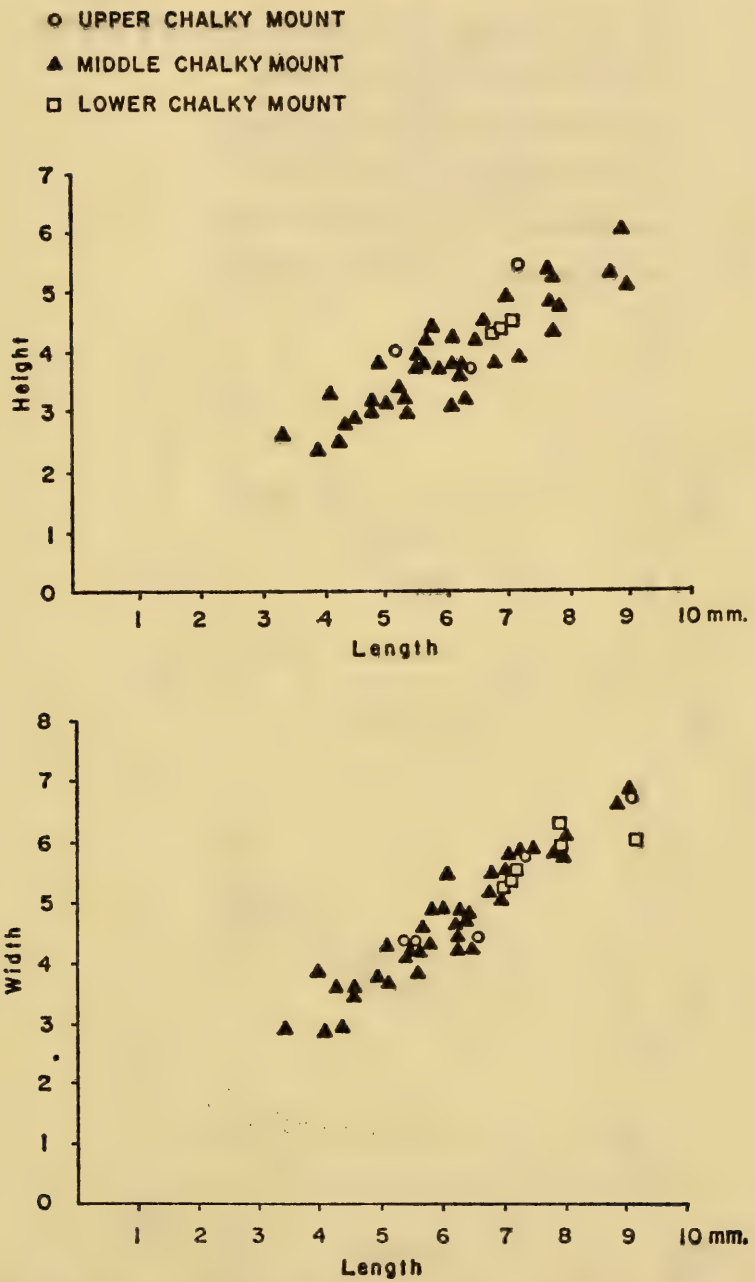


Fig. 9.—*Fibularia barbadosensis* Kier, new species: Relation of the height and width to the length in specimens from the Lower, Middle, and Upper Chalky Mount Members of the New Scotland Formation.

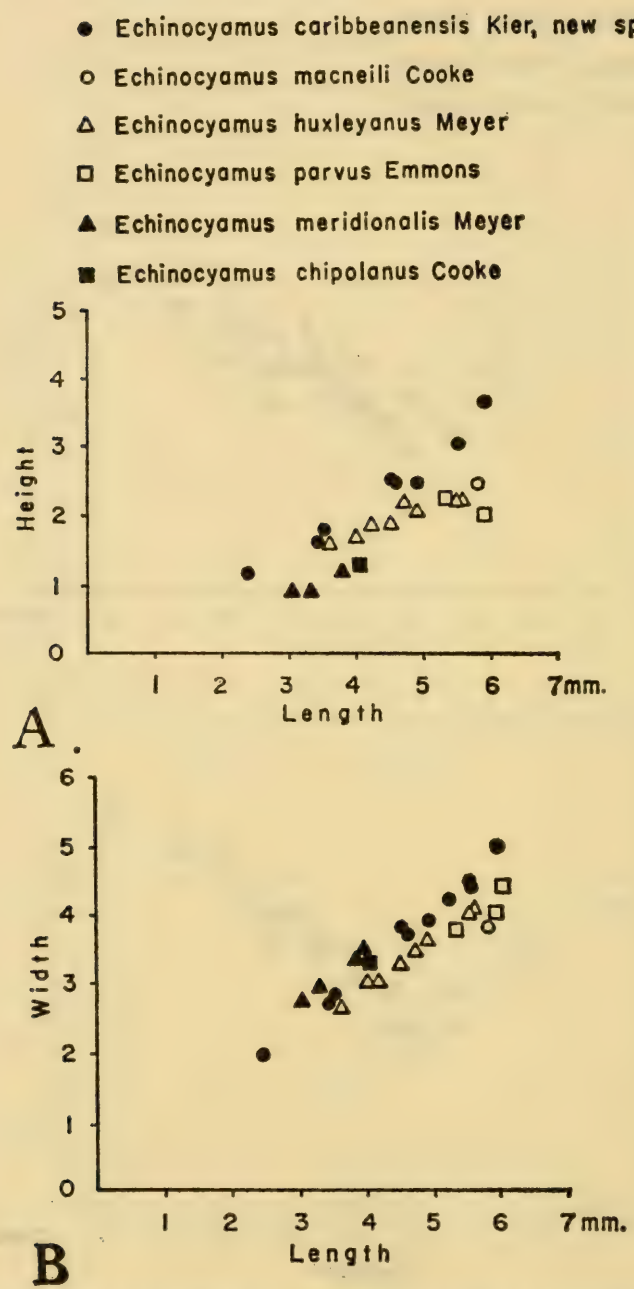


Fig. 10.—A, B, Relation of height and width to length in five species of *Echinocyamus* from eastern America for comparison with *Echinocyamus caribbeanensis* Kier, new species.

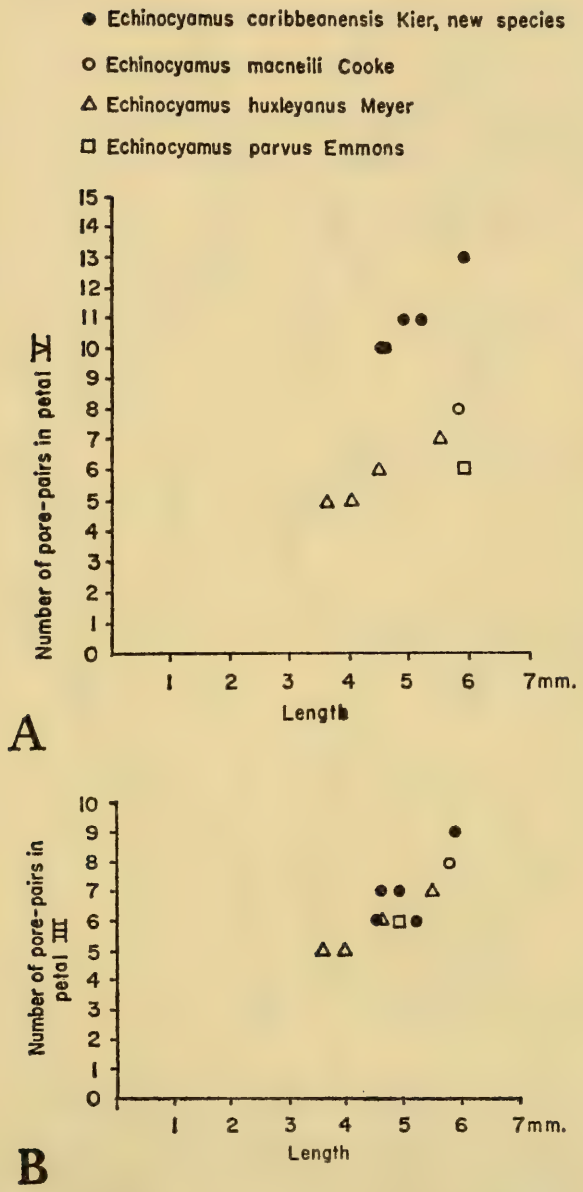


Fig. 11.—A, B, Relation of number of pore-pairs in one poriferous zone in petals V and I to the length of three species of *Echinocyamus* from eastern America for comparison with *Echinocyamus caribbeanensis* Kier, new species.

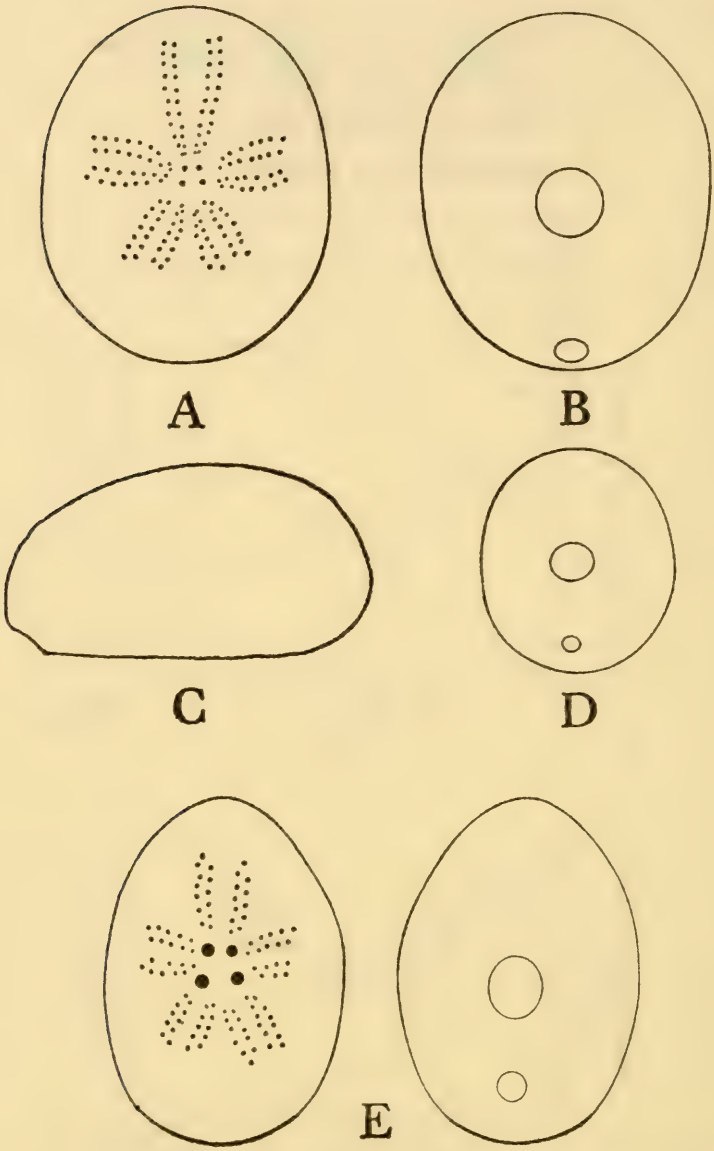


Fig. 12.—**A–D,** *Echinocyamus caribbeanensis* Kier, new species: **A–C,** Adapical, adoral, right side of holotype, Basel M6605, loc. S80, × 10; **D,** Adoral view of Basel M6606, loc. S1107, showing more anterior position of periproct in largest specimen (5.9 mm long), × 5. **E,** *Echinocyamus huxleyanus* Meyer: Adapical and adoral view of USNM 499001, Geneva, Alabama, × 10.

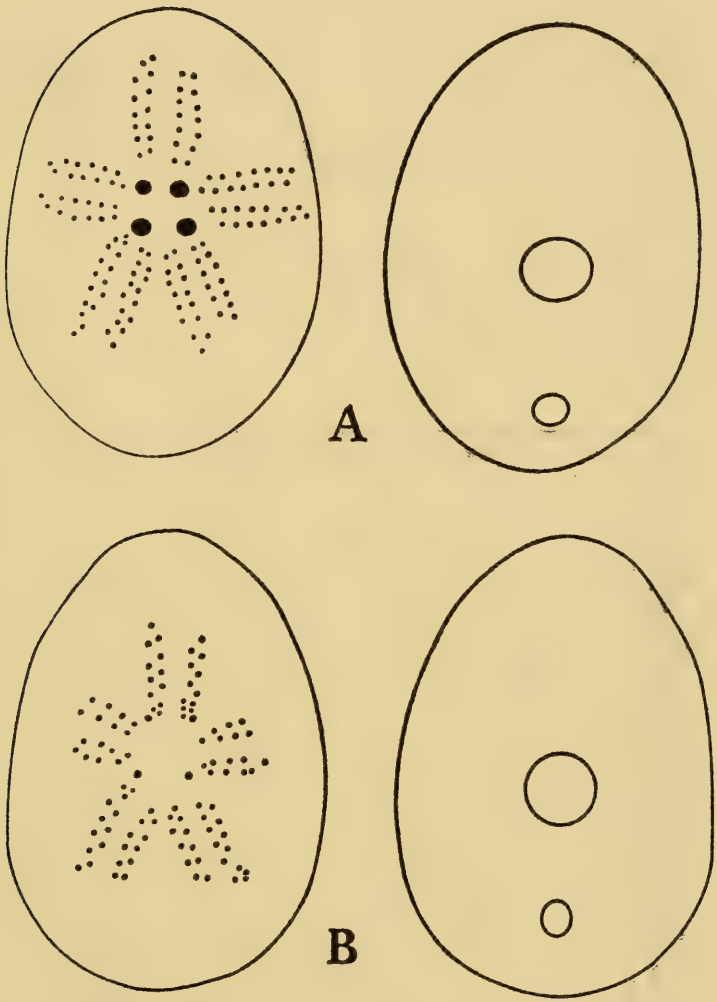


Fig. 13.—**A**, *Echinocyamus macneili* Cooke: Adapical and adoral view of holotype, USNM 562297, from late Eocene equivalent of Moodys Branch Formation at USGS 15562, creek flowing into Conecuh River in the NE ¼ sec. 32, T. 4 N., R. 15 E., Covington County, Alabama, × 10. **B**, *Echinocyamus parvus* (Emmons): Adapical and adoral view of USNM 499002, from middle and late Eocene Castle Hayne Formation at USGS 10363, J. M. Thomas' farm 10 miles north of Jacksonville, Onslow County, North Carolina, × 10.

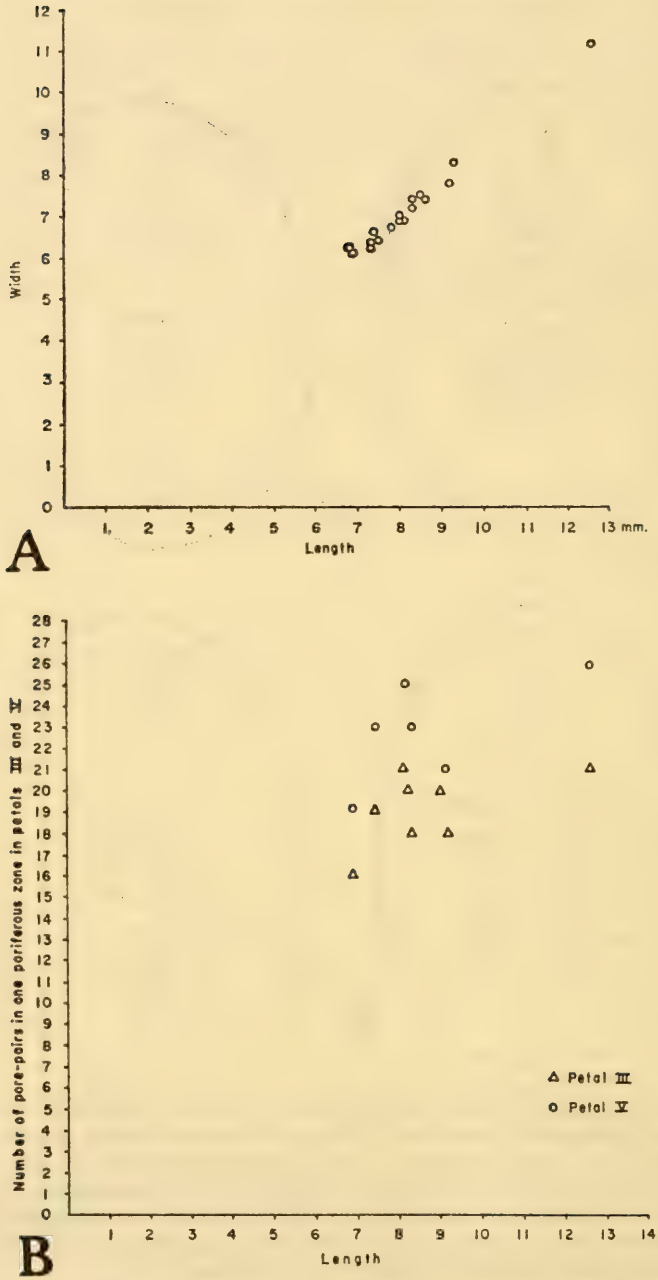


Fig. 14.—*Cassidulus senni* Kier, new species: **A**, Width relative to length; **B**, Number of pore-pairs in one poriferous zone in petals III and V.

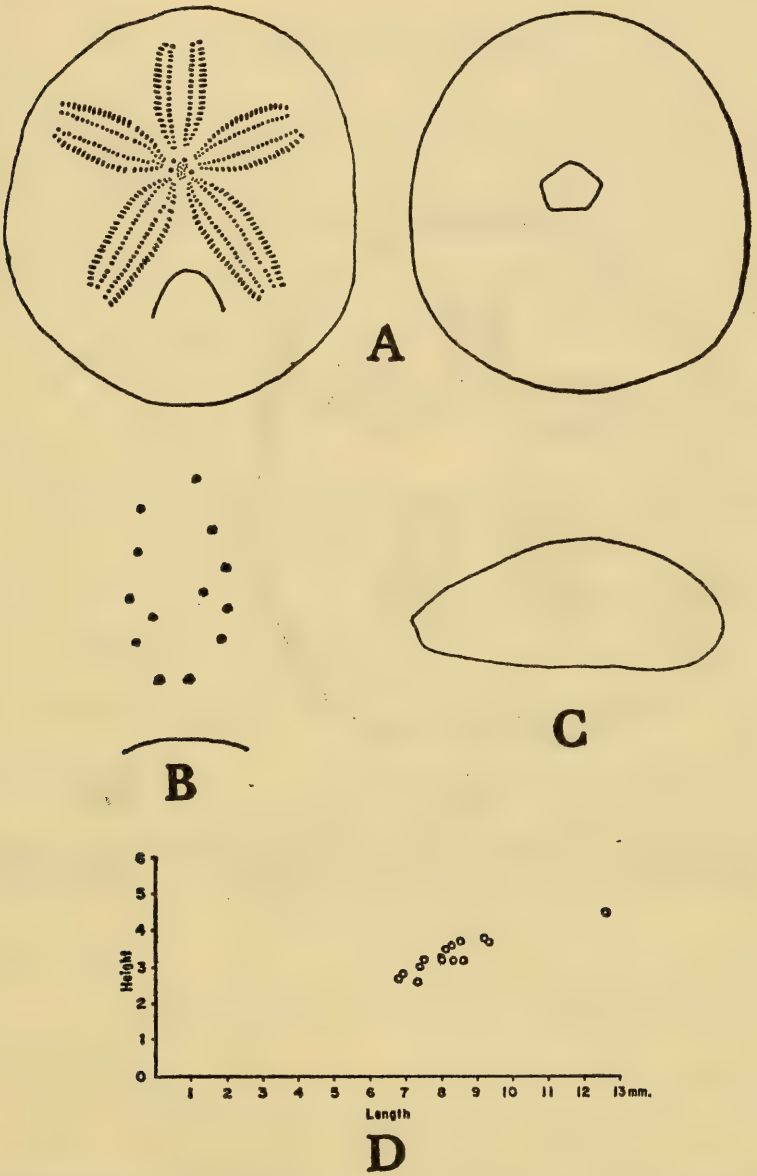


Fig. 15.—*Cassidulus senni* Kier, new species: **A**, Adapical and adoral view of holotype, M6607, loc. S152, × 4; **B**, Phyllode of ambulacrum V of M6608, loc. S80, × 30; **C**, Right side view M6608, loc. S80, × 5; **D**, Relation of height to length.

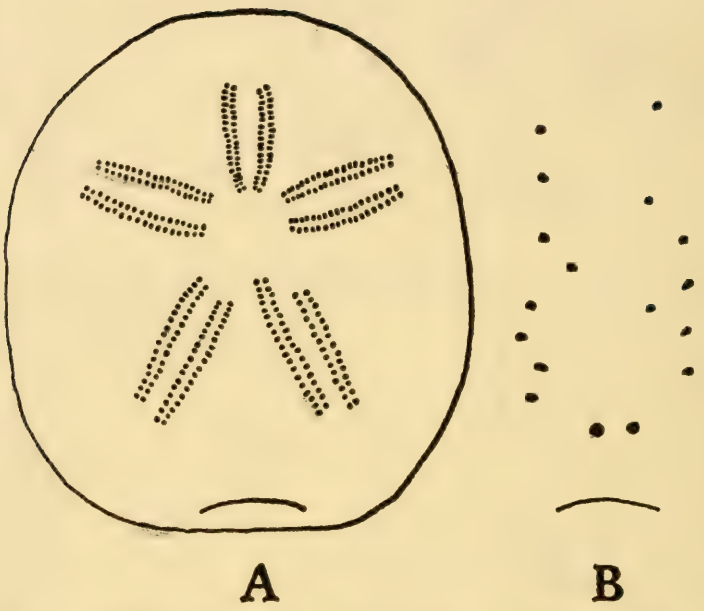


Fig. 16.—*Cassidulus mestieri* Kier, new species: **A**, Adapical view of holotype, M6610, loc. S164, × 5; **B**, Phyllode of ambulacrum II of holotype, × 25.

LITERATURE CITED

COOKE, C. W.

1959. Cenozoic echinoids of eastern United States. Geol. Surv. Prof. Paper 321, 106 pp., 43 pls.

CIZANCOURT, M. DE

1948. *Nummulites* de l'île de la Barbade (Petites Antilles). Mém. Soc. Géol. France, new series, vol. 27, No. 57, pp. 5-36, map, 2 pls.

GREGORY, J. S.

1889. *Cystechinus crassus,* a new species from the Radiolarian marls of Barbados, and the evidence it affords as to the age and origin of these deposits. Quart. Journ. Geol. Soc. London, vol. 45, pp. 640-650, figs. 1-3.

1892. *Archaeopneustes abruptus,* a new genus and species of echinoid from the Oceanic series in Barbados. Quart. Journ. Geol. Soc. London, vol. 48, pp. 163-169, pl.4.

GUPPY, R. J. LECHMERE

1911. On the geology of Antigua and other West Indian islands with reference to the physical history of the Caribbean region. Quart. Journ. Geol. Soc. London, vol. 67, pp. 681-700, pl. 50 [map].

KIER, P. M.

1957. Tertiary Echinoidea from British Somaliland: Journ. Paleontology, vol. 31, pp. 839-902, 5 pls., 20 text figs.

1962. Revision of the cassiduloid echinoids: Smithsonian Misc. Coll., vol. 144, No. 3, 262 pp., 44 pls., 184 text figs.

1964. Fossil echinoids from the Marshall Islands: Geol. Survey Prof. Paper 260-GG, pp. 1121-1126, pl. 302, text figs.

LAMBERT, J.

1931. Note sur le groupe des *Oligopygus* la nouvelle famille des *Haimeidae* et sur quelques Échinides fossiles de Cuba. Bull. Soc. Géol. France, 5th ser., vol .1, pp. 289-304, pl. 17.

MORTENSEN, TH.

1948. A monograph of the Echinoidea, vol. 4, 2 Clypeastroida, 471 pp., 72 pls., 258 text figs., Reitzel, Copenhagen.

SENN, A.

1940. Paleocene of Barbados and its bearing on history and structure of Antillean-Caribbean region. Bull. Amer. Assn. Petr. Geol., vol. 24, pp. 1548-1610.

TRECHMANN, C. T.

1925. The Scotland beds of Barbados. Geol. Mag., vol. 62, pp. 481-504.

VAUGHAN, T. W.

1945. American Paleocene and Eocene larger Foraminifera. Geol. Soc. Amer., Mem. 9, part 1, 120 pp., 46 pls.

WELLS, J. W.

1945. West Indian Eocene and Miocene corals. Geol. Soc. Amer., Mem. 9, part 2, 25 pp., 3 pls.

WITHERS, T. H.

1926. Decapod crustaceans (*Calianassa*) from the Scotland beds of Barbados. Geol. Mag., vol. 63, pp. 104-108.

EXPLANATION OF PLATE

Fibularia barbadosensis Kier, new species

1, 2, 3, Adapical, right side, and adoral view of holotype, Basel M6603, loc. S1107, × 5.

Echinocyamus caribbeanensis Kier, new species

4, 5, Adapical and adoral view of holotype, Basel M6605, loc. S80, photographed in alcohol, × 9.

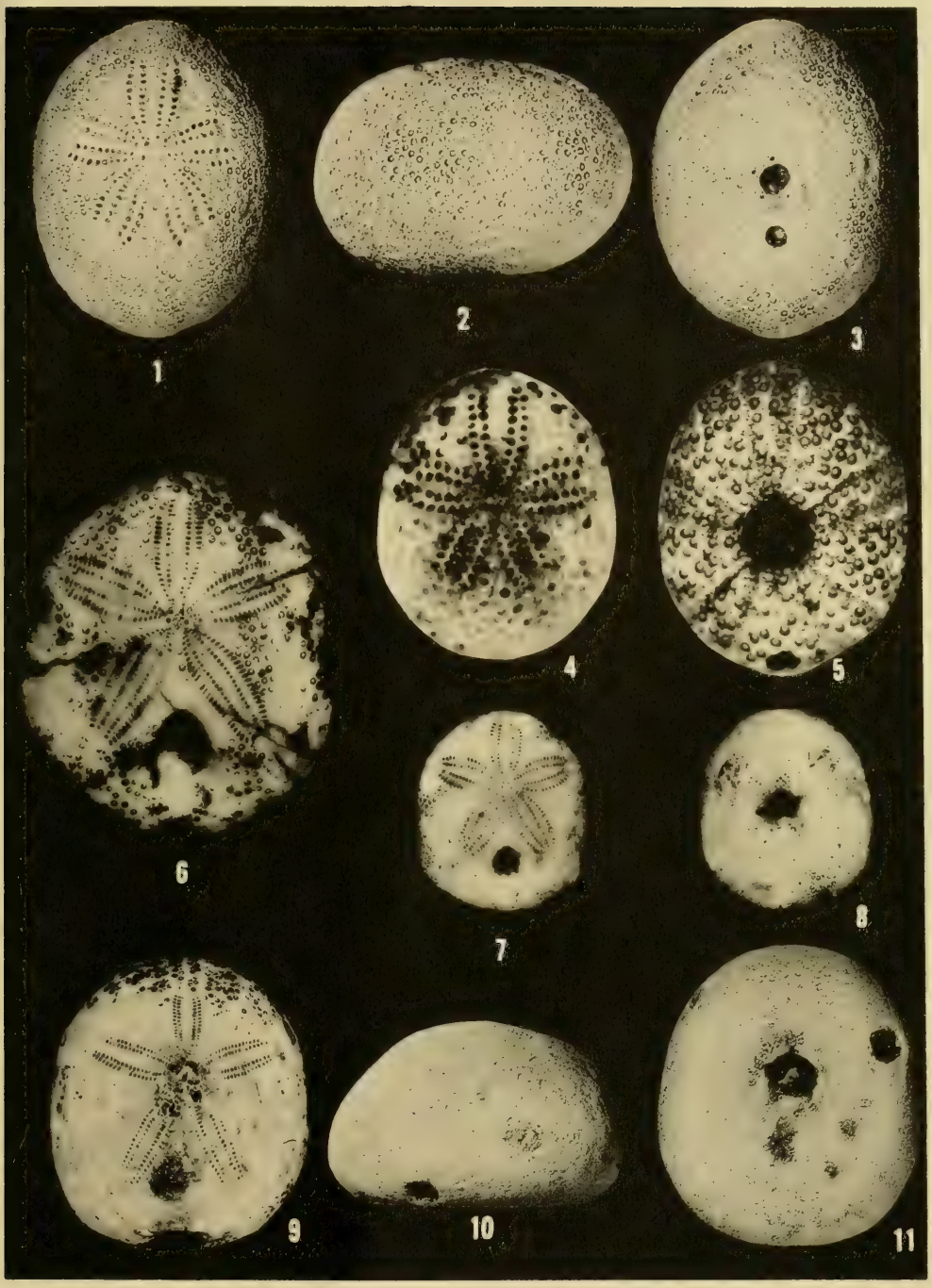
Cassidulus senni Kier, new species

6, Adapical view of holotype M6607, loc. S152, photographed in alcohol, × 4.

7, 8, Adapical and adoral view of M6609, loc. S152, photographed in alcohol, × 4.

Cassidulus mestieri Kier, new species

9, 10, 11, Adapical, left side, adoral view of holotype M6610, loc. S164, adapical view photographed under alcohol, × 3.



1, 2, 3, FIBULARIA BARBADOSENSIS KIER, NEW SPECIES; 4, 5, ECHINOCYAMUS CARIBBEANENSIS KIER, NEW SPECIES; 6, 7, 8, CASSIDULUS SENNI KIER, NEW SPECIES; 9, 10, 11, CASSIDULUS MESTIERI KIER, NEW SPECIES